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Household and farm transitions in environmental context

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Abstract

Recent debate in the literature on population, environment, and land use questions the applicability of theory that patterns of farm extensification and intensification correspond to the life course of farmers and to the life cycle of farm families. This paper extends the debate to the agricultural development of the United States Great Plains region, using unique data from 1875 to 1930 that link families to farms over time in 25 environmentally diverse Kansas townships. Results of multilevel statistical modeling indicate that farmer's age, household size, and household structure are simultaneously related to both the extent of farm operations and the intensity of land use, taking into account local environmental conditions and time trends as Kansas was settled and developed. These findings validate farm- and life cycle theories and offer support for intergenerational motivations for farm development that include both daughters and sons. Environmental variation in aridity was a key driver of farm structure.

Keywords

Household; Life cycle; Land use; Agriculture; Semi-arid; Kansas

Introduction

Changes across a farmer's life cycle, the size and composition of the farm household, and the environment in which the farmer is operating have all been posited as key correlates of farm extensification and intensification across a wide body of literature. Agricultural economics builds on firm size distributions, and labor needs to show the importance of the farmer's age in determining the development of the farm. These patterns are significantly shaped by the context in which farmers operate. Some of that context is historical, in the sense that farmers who arrived near the time a region was settled may have different experiences through their lives than do those who began their farming career after a region was well established. Environmental context is also a critical consideration. If farm size indicates how farmers experience their professional and economic lives, then the place they farm and the way place shapes farm activities are important in understanding that experience. A significant body of recent literature about environment, farms, and families informs our thinking about this relationship. Finally, the nature of households in economic

context informs us about the role of consumption and production in understanding farms and families in both the long and short terms.

In this paper, we use a unique body of longitudinal linked data to analyze the relationship between farm and family in the United States in the late-nineteenth and early-twentieth century. These data allow us to show variations in farm and farmer experience by age, across a relatively long time period, and with environmental variation, for households with a diverse array of structures, from young childless couples, through families with teenage children and children in the twenties, to empty nesters in their sixties and seventies. The ability to differentiate between sons and daughters—and therefore to tease out information about the role of labor, consumption, production, and capital in motivating farmers to increase or decrease the size of farms and the amount of land in crops—adds to the strength and nuance of our conclusions. Our dataset does not include all of the information necessary to understand causality, and disentangling the role of production, consumption, and capital formation with our data is very difficult. Nonetheless, we reach important new conclusions about the coproduction of farm and family, and about the contribution of each member of the family to the changing experience of the farm.

Agricultural economics provides the best starting point for theorizing a connection between life cycle and land use in agriculture by linking the development of family farm size to the literature on firm size distributions (e.g., Boehlje 1973; Sumner and Leiby 1987). This work describes three stages in the farm life cycle, corresponding to the operator's age: entry and establishment early in the farmer's career; growth and survival; and divestment as the farmer moves toward retirement and liquidates or transfers the farm (Boehlje 1973; Gale 2003; Gale 1994). Young and entering farmers have smaller farms because they have less access to capital, although intergenerational transfers or the availability of "free" or inexpensive land can mitigate this relationship (Atack et al. 2002; Potter and Lobley 1992). Farms grow and survive by intensifying land use and expanding land holdings, as farmers obtain access to credit and to their children's labor, and as they take increasing risks. When the farm approaches an optimum scale of operations, growth slows. Finally, farmers scale back their holdings and activities as their family labor supply diminishes and they transfer, rent, or sell land in preparation for retirement. With fewer dependents, the older farm household may shift activities to those with a longer wait time on returns to investment or those that require less labor. Age proxies both the farmer's career development and the family life course, along with changing abilities, needs, and motivations (Burton 2006). Agricultural economists document an age pattern of farm extensification, intensification, and divestment when describing these processes. While implicit in the discussion, few studies in this field explicitly consider family size or the age and gender composition of households beyond the need to identify a farm successor and the potential for off-farm sources of income.

This generalized age trajectory of farming is subject to variation across environmental and historical contexts. It is widely agreed that environmental conditions largely determine the types of agricultural activity that will succeed, the possible or necessary scale of farm operations, and the risks associated with different farm strategies (Angelson 2007; Davis 1929; Malin and Swierenga 1984; Moran et al. 2005; Pfeffer 1983; Sherow 2007; Sylvester and Cunfer 2009; VanWey et al. 2007; Walker 2003; Walsh et al. 2005). A number of variables come into play in these findings, the most important being soil quality, terrain, native vegetation, precipitation, and drought. These variables contribute to the size of enterprise, approach to land use, and profitability, which in turn interact with the age of the farmer, the role of consumption and production, and the pace at which farm enterprises change through the life cycle. Farmers also operate in specific historical settings. Much of the recent literature about family and farm in environmental context concerns itself with frontier land in developing economies, where the pace of settlement and national economic

development are the keys to understanding how farmers move through their lives and manage their families. Those findings demonstrate the importance of the specific place and time where farmers establish themselves and operate. Late-nineteenth- and early-twentieth-century Kansas was also a frontier setting in a developing economy, but broader demographic developments, such as the fertility decline, trends in labor and technology, and the historical record of drought are also salient in our setting for understanding the size and structure of families, the pace at which population changed through reproduction and migration, and the economic resources that farmers required to establish and sustain their businesses.

Models of agricultural household behavior building on Chayanov (1966), particularly the work of Squire and colleagues (Barnum and Squire 1979; Singh et al. 1986), treat farm households as sites of both production and consumption, and link these activities to size and composition (see Taylor and Adelman 2003). Large households may demand large farms because of the number of consumers or they may create large farms because of the number of producers (e.g., Béaur 1998; Clay and Johnson 1992; Hedican 2006; Stokes and Schutjer 1984). Moreover, size and composition must be conceptually separated to account for the different abilities, motivations, and roles of various farm household members. Family labor has historically been a key aspect of farm life, legitimizing a labor-oriented approach that views household composition and land use as closely linked (e.g., Atack and Bateman 1987; Bennett 1982; Cain 1977; Craig 1991; Grimes 1931; Sylvester 2001a). Children work on the farm but are also consumers in wealth-flow bargains that have implications for farm strategies and home-leaving decisions (Caldwell 1976, 2005; Carter et al. 2004; Gjerde and McCants 1999; Gutmann et al. 2002). Moreover, agricultural work and rewards tend to be age and gender specific. The work of women and children is crucial to farm enterprises, but specific strategies might depend on the balance of sons and daughters due to different expectations related to the potential for immediate or deferred intergenerational transfer of accumulated capital (Adams 1994; Fink 1987; Flora 1985; Flora and Stitz 1988; Hunter and Riney-Kehrber 2002; Kim and Zepeda 2004; Kohl and Bennett 1982; Leonard and Gutmann 2006; Neth 1994, 1995; Osterud 1991; Potter and Loblely 1992). Similarly, resident hired labor increases household size, but these household members do not fit into succession plans, except as a means to realize them (Atack et al. 2002; Craig 1991).

The most detailed recent work on household demography and land use is set in the developing world and pays attention to structural differences in household strategies based on the age and gender of household members (Barbieri et al. 2005; de Sherbinin et al. 2008; Fox et al. 2003; Lee and Kramer 2002; McCracken 1999; Moran et al. 2003, 2005; Perz 2001; Perz et al. 2006; VanWey et al. 2007; Walker and Homma 1996; Walker et al. 2002; Walsh et al. 2005). In a review of the literature on the Amazon, Walker et al. (2002) found that household size and head's age generally did not have significant effects on land use and land-use change (see Table 2, pp. 179–182), potentially because analyses did not include household composition characteristics (de Sherbinin et al. 2008; Walker et al. 2002). More recent work has explored household composition in a life cycle framework, which allows both the age (or tenure) of the household head and the number, gender, and ages of household members to be related to land use. Perz, Walker, and Caldas (2006) found the number of adults and children in the Amazon to be positively associated with intensive land uses and negatively associated with extensive land use. VanWey et al. (2007) highlight the mixed results of this body of work, finding no support for household life cycle theory in explaining land-use change in their Amazonian research sites. Rather, much like the situation in developed countries (Hoppe 2001; Key and Roberts 2007; Kim and Zepeda 2004; Riney-Kehrberg 2001; Weiss 1999), off-farm sources of income, such as women's wages and government program payments sustained agricultural activities. In addition to exploring the relationship between household demography and land use, this research

investigates both the consequences to physical environments of land-use change and the role of physical environments in land-use choices.

Although the results of investigations into the relationship between household demography and land use have been mixed, the implications of household structure for the farm life cycle resonate across the work cited previously. Economic studies tend to view the farmer as an entrepreneur, focusing on career trajectories, viability, and continuance of the farm business. Operator's age, and to some extent the presence of a successor, carries explanatory weight, especially for changes in farm size. Historical, sociological, and anthropological studies generally acknowledge role differentiation among household members by age, gender, and relationship to the farm operator. They also recognize the effects of household composition on labor, production and consumption decisions, including motivations for long- and short-term household economic strategies. Studies differ in whether they posit farmer's life course, the household life cycle, the size of the household producer and consumer pool, or the specific age, gender, and relationships between household members as the critical element connecting family size and structure with farm extensification and intensification. Their varied findings suggest that production, consumption, growth, old-age security, and succession motivations may operate simultaneously and also feed back into future land-use decisions. Increasingly, scholars also acknowledge the role of physical environmental endowments in land use, and that of settlement in land-use change.

Specific theoretical ideas from these earlier studies guide our analysis of the historical development of family farming in Kansas. Farming households function to provide for members over the life course at least in part by adapting their land-use behavior to current and projected needs and resources, within the constraints and opportunities afforded by the place and time in which they are farming. Land-use extensification and intensification follow a farmer's life course. The magnitude and direction of land-use change varies across the life of the farm operator to form a non-linear trajectory of land use, consisting of the phases of farm establishment, investment and growth, and divestment. The theoretical relationships between farmer age, family size, farm extent, and amount of cropland (the major form of land intensification across Kansas) are illustrated in a very simplified way in Fig. 1. Farm families are often supplemented by employees. Smaller or larger households, made up of different combinations of males and females, relatives or employees, and of varying ages, will influence the form of these relationships through their different contributions to and demands on the farm livelihood. Activities that affect land use and land-use change are simultaneously oriented toward maximizing profit for the business enterprise and providing for current and future consumption needs of family and household members. Variations in farm trajectory should be responsive to environmental endowments and historical events or trends, as these factors alter farmers' willingness or ability to enter into farming, expand the farm operation, curtail cropping, and transfer land. We will therefore examine the following specific hypotheses:

- First, land-use extensification and intensification follow farmers' life cycles, and the magnitude and direction of those linkages vary across life of the farm operator.
- Second, the form of the farm life cycle varies with environmental endowments (e.g., flatter in areas where farms may be smaller) and historical contingencies (e.g., less divestment in frontier times).
- Third, the farm life cycle is linked to household demography such that male or female members of different ages have different implications for the farm life cycle (e.g., farmers who start their families earlier may start intensifying cropping earlier). This is the most significant part of our analysis because it connects to the

stages of the life cycle (establishment, investment, and divestment) and to the critical questions of the role of consumption and production.

- If farm size is more closely related to overall size of household and to numbers of younger children, then consumption is the dominant issue, while if farm size is related to numbers of adolescent boys and adult men, production capacity is the dominant explanation.
- We recognize the importance of income from off-farm and non-cropping farm activities as a source of investment, which may result in increased farm size, or may alternatively allow for earlier divestment. These sources of income may be difficult to measure, but we believe that the presence of adult women (daughters and daughters-in-law) without children is a potential indicator.
- At the time of divestment, the relationship between farm and family will not necessarily follow predicted patterns related to production, consumption, and investment. This is important because we believe that households on the verge of divestment may include adult sons without a concomitant increase in farm size, and that farm households after divestment may be reoriented toward consumption and thus have farm attributes that we may not be able to predict.

In the balance of this paper, we first describe the database we have constructed and the setting, including environmental variation, changing farm structure, and aspects of changing populations. We then explore the hypotheses outlined previously and discuss the implications of our findings for understanding production and consumption in gendered and intergenerational strategies of farm families.

Context and data

The data we use in this paper are drawn from a larger database of linked individual-level population and farm census records for 1860 through 1940 for 25 Kansas townships in 25 different counties, nested within five broad agro-ecological regions (Sylvester et al. 2002). These counties represent the full variety of environmental conditions and time of settlement within the state, which in turn reflect environmental and historical variation in the larger Great Plains region. We chose Kansas for this project because, within the broad central portion of the United States, it has uniquely rich data about population and agriculture that were collected by both the federal and state governments. To support our focus on farm households across environmental regimes, we selected the township within each county with the highest population density in 1910, but that did not contain the county's concentrated population center. This strategy focused our sample on the most arable land in each county, giving us a diversity of farms along a continuum of heavily cropped to predominately pasture. A random selection of townships within the target counties ran the risk of producing a) unacceptably small samples that b) did not reflect the full county distribution of farms and ranches, particularly in the western counties. Detailed information about people and farms is a strength of our study. Our database includes direct measures of farm extent and intensive agricultural land use. We are able to include in our analysis all three theoretically important household demographic attributes: the age of the head, the number of individuals in the household, and their distribution by age, sex, and inferred relationship to the household head. Importantly, we observe farm households across a continuum of environmental conditions important to agricultural strategies and to the scale of farms, and from the beginning of agricultural settlement—when human labor was perhaps the key element determining whether farmers realized their goals—to the eve of modern, mechanized, capital-intensive farming.

Context: Settlement in Kansas began before the US Civil War, accelerated after the Homestead Act of 1862 and grants to railroads opened more public land, and reached the western boundary by the end of the 1880s. The eastern portions were settled in the mid-1850s, before statehood and during a time of political and social upheaval. Settlement proceeded generally from east to west across the state, with lands best suited for farming settled first and more densely and the drier lands in the west settled later and with lower density (Gutmann et al. 2010). There was an active market in land from the beginning of settlement, and most farmers acquired their land through means other than the Homestead Acts. The federal government offered land for sale and deeded large tracts of land to states, individuals, and corporations, most notably railroads. Land became more expensive over time, partly because speculation drove prices up, but also as land available through the less expensive government programs (preemption, homesteading, and auction) was purchased, and as quality differences between particular parcels of land became evident (Atack et al. 2002; Opie 1987; Shannon 1989 [1945]). A farmer could also acquire land through inheritance or *inter vivos* gift or sale, but the continuing opportunity to acquire low-cost land on the frontier until about 1920 may have discouraged heirs from waiting for intergenerational transfers.

Farm sizes were dominated by a structural artifact: the mile-square grid of the Public Land Survey System divided the region into 640 acre “sections,” further divided into the 160-acre “quarter-section” allotments of the Homestead Act of 1862. As late as 1905, the median farm in our sample remained at 160 acres. Cropping acreage increased over time as native grasslands were plowed and planted. Land continued to be integrated into farms in the eastern townships until about 1905, and until about 1920 in the western townships. Thereafter, total farm acreage stabilized, the number of farms decreased and then leveled off, and land gradually shifted from small and mid-sized farms to larger farms. Extremely large farms in Kansas were generally fleeting enterprises. Corporate farms are not included in our analysis of farm households and were a small and short-lived phenomenon declared illegal in 1931 (Grimes 1931; Miner 2002, 2006).

The region was completely settled by the 1890s, and the population growth rate almost immediately flattened, becoming negative by 1930 (Ostterstrom and Earle 2002). Population in the Kansas townships in our data peaked around the year 1910, just as labor-saving agricultural technology began to be adopted. Major droughts in the 1860s, early 1870s, early 1880s, 1894–1895, and the 1910s may have delayed or reversed settlement in some parts of the state (Blackmar 1912; Cutler 1883; Flora 1948; Holloway 1868; Worster 1994). Over time population turnover diminished, more of the population was native-born, families were smaller, populations and farmers aged, farms became larger with some consolidation evident from the early-twentieth century, and out-migration of the younger generation began. Major population centers developed at Kansas City, Topeka, Wichita, and Dodge City, and each county had a town at its seat, with many small villages and hamlets scattered across the countryside. Rural population decline was largely driven by a developing economy in the state and growing industrialization in the nation. Opportunities to earn a living outside of agriculture or to supplement farm income became more important as rising land prices and falling rural wages made making sustaining the farm more difficult.

Comparing occupations from one census to the next reveals both upward and downward mobility for farmers and farm laborers in the sample townships. While occupational change is not the best means to measure social status and social mobility in an agricultural community, information to establish tenancy is not consistently available from the records, and we are not able to place households on the rungs of the agricultural ladder (Atack 1989; Bogue 1963). Most farm household heads remained farmers, but about one-fifth were later enumerated as tradesmen and a small percentage were reported as agricultural or unspecified

laborers. Men who appeared as farm laborers in one census were quite likely to be enumerated as farmers in the subsequent census (62%), but most of these were farm sons establishing their own farm households. Very few heads of household were farm laborers, but they showed remarkable mobility, with half listed as farmers in the next census. Farmers who were not household heads showed both upward and downward shifts in occupation, with slightly over half remaining farmers in the next census and one-third next listed as agricultural laborers. The percentage of the farm sector enumerated as farm laborers rose over time; many townships had no farm laborers in the early years, but by 1920, nearly one-quarter of the agricultural labor force in some townships worked on someone else's farm. Higher percentages of farm laborers were associated with more acres in production at the township level. Townships with smaller farms and fewer acres in crops, as well as those in the less-arid east and nearer to larger towns and cities, had higher percentages of adults employed outside of agriculture.

In historical Kansas as elsewhere, farm families implemented livelihood strategies in the context of environmental opportunities and constraints. Settlement loosely followed a moisture gradient that, in combination with soil quality, temperature, wind, and topography, largely dictated what farmers could grow. Kansas becomes higher and drier from east to west, gaining some 2,000 feet in elevation and losing about 15 inches in annual rainfall. Sharp gullies cut through the land surface in some portions of the state, rendering it unsuitable for cropping. While the basic characteristics of climate, elevation and landform across Kansas are well understood, important information about weather (precipitation, temperature and wind) is unavailable for the early years of settlement. Instead of relying on scant data about weather, we base our environmental classification on the work of James Malin (1947, 1955), who identified five land-use zones that capture variation in environmental characteristics salient for agriculture (Fig. 2). The households in our sample are roughly evenly divided among the Mixed Farming, Corn Belt, Bluestem Pastures, Central Wheat Belt, and Wheat Cattle Sorghum agro-ecological zones, which exhibit significant variation in farm size and cropping as well as in environment (Table 1). While these zones are more than adequate for the purposes of this article, in which we attempt to assess the role of environment in a broad context, we leave for future research an analysis of the interaction of basic environmental regime and changes in weather at the annual or decadal scale.

Each of the five zones described by Malin has its own characteristics. The Mixed Farming zone has the most precipitation and can support most types of agricultural activity. It is also the lowest in elevation and has significantly less non-productive farmland than the other cropping zones. The Bluestem Pastures zone, in the region known as the Flint Hills, has more productive soil and receives enough precipitation for continuous cropping and good pasture, but rocky limestone soils interfere with cultivation. The Corn Belt has significantly lower summer and winter temperatures and the highest percentage of non-productive farmland. This area has adequate moisture for corn, but topography and soil quality less well suited to wheat cultivation. The Central Wheat Belt is too dry for reliable corn crops, with lower precipitation and July humidity, but has nearly perfect weather conditions for growing wheat and little poor-quality farmland. Development of this area during the 1870s helped shift the Kansas economy from cattle to crop production. The Wheat Cattle Sorghum zone is higher and drier than the rest of Kansas. Gullies and breaks cut expanses of smooth prairie, contributing to the high percentage of non-productive land. Farms and ranches were generally larger in the west, because drier land requires more acres to support crops or livestock. As a result, farm size and acres in crops have an inverse relationship with moisture availability. Farms were significantly larger and had more cropped acres in the Wheat Cattle Sorghum and Central Wheat Belt zones. The two easternmost zones, Mixed Farming and Bluestem Pastures, were similar in that they had smaller farms and fewer

cropped acres than the wheat-growing zones. The Corn Belt, with the highest proportion of poor farmland, had smaller farms than the other zones, but more acres in crops than the eastern areas.

Data: The Kansas State Board of Agriculture conducted population and agricultural censuses every 10 years on a schedule complementary to that of the US Federal censuses beginning in 1865 and continuing until 1925, when the full population enumeration ceased. Taken together, the state and federal records provide data on population and agriculture every 5 years from 1860 to 1925, except for 1890 (no records available) and 1900 and 1910 (no agricultural records). The Kansas censuses were modeled on the US censuses as they changed over the decades. Both sets of data are rich in information, with one to three dozen questions about individuals and scores of questions about farm activity. The Kansas population census lacks some key questions that the federal census includes; most notably, relationship to the head of household was not asked until 1925 and birthplace of parents was never asked. Individual farm returns no longer exist for the later US agricultural censuses; all agricultural data beginning in 1885 are from the Kansas censuses, including those in 1920 and 1930. The key difference between the Kansas and available Federal agricultural censuses is a focus on land use in the current growing cycle in the Kansas censuses (e.g., acres sown or to be sown) in contrast to production data collected by the Federal census (quantities of produce on hand or sold). The exact location of lands farmed and how the land was incorporated into the farm (including whether rented or owned) were not recorded in these sources of individual-level data (except for tenure data in 1920).

The data are unique because all the available records for each household and farm from disparate federal and state sources have been brought together into a single analytic body. Individual-level records from population census have been linked to agricultural censuses and linked from each population census to the next, using computer-assisted manual linkage based on name, age, and birthplace, with contextual information (such as the names of family members) used to improve linkage quality (Sylvester et al. 2002). Linkage was very complete between agricultural and population censuses, with 92% of farms in the agricultural census linked to an individual in the population census. Linkage rates between individuals were often very low between the censuses immediately following settlement (reflecting low levels of persistence in the early years), but increased to average nearly 60% across all townships by 1925 (calculated as the percentage of those linked to the previous census, to accommodate enumeration district divisions). Restricting the present analysis to farming households enumerated in censuses with directly comparable agricultural data (every 10 years from 1875 to 1925, plus 1920 and 1930) produces a dataset with 16,091 observations of 9,769 farming households. There are roughly 2,000 households in each census year except 1875, when there are fewer (nearly 1,500) because the western townships were then only partly settled. Among households, 36% were observed only once. Over time, the percentage of one-observation households declined from 36% in 1875 to 15% in 1925. These trends in persistence and record linkage success reflect migration, enumeration district boundary changes, potential changes in allocation of headship, and increasing frequency and information content of the data sources over time, with fewer instances of data missing for entire townships.

Our two dependent variables, farm size and acres in principal crops, come from the agricultural census records. Both the Federal and Kansas farm censuses used an operational definition of farms. The farm operator reported on all activity and acres he or she managed, regardless of whether the acreage was owned or rented. Farm size is the number of acres comprising the farm as reported on the census, summed across households. To maintain a focus on productive family farms, households with farms smaller than 10 acres, or larger than 2,560 (4 square miles) are not included in the analysis. Cropped acres is a sum of the

total of acres sown or to be sown at the time of the census in the principal crops grown as cash crops or to be fed to livestock (wheat, corn, oats, barley, rye, and sorghum). Comparability in the reporting of crops, particularly whether as yields or acreages, and availability of agricultural census micro-data, restrict the analysis to the years 1875, 1885, 1895, 1905, 1915, 1920, 1925, and 1930.

Farm households are the unit of analysis. We define households based on dwelling as identified by the census enumerator, in order to incorporate non-family members as contributors to the overall labor pool available to farmers. Non-household dwellings (group quarters, army barracks, railroad camps, etc.) are not included in the analyses, nor are dwellings not identified as group quarters that include more than 21 persons. The first person listed in a dwelling is considered to be the head, in keeping with enumeration instructions, and change in headship was considered a new household. In these rural settings, it is not surprising that the enumerator identified more than one census family in only 2% of census dwellings. However, many households were not simple nuclear families. One in five was augmented with at least one unrelated adult, and one in eight had a co-resident adult child. Farm households were identified as those where one or more members linked to an agricultural census record in the same year. Bogue's "farmers without farms" (Bogue 1963), farms operated by non-residents, and corporate farms are not included in the analyses.

Age and sex of household members are as reported on the census, standardized across observations for those we linked forward from one census to the next. Relationship of other members to the household head was never asked in the Kansas state census, and was not asked on the federal census until 1880. Consequently, relationship to household head was inferred, with last name similarity and difference in age identifying spouses, children (including adult children), and others. Because of the limitations of the data, sons-in-law, married daughters, step-children, and other relatives are indistinguishable from hired hands, servants, boarders, and lodgers. The role of household members and their relationship to labor and land use are theorized to differ by relationship to the household head, age, and sex. We divide head's adult children into those below the median age for leaving home (18–22), those above the median age but still within the range of home leaving (23–29), and those old enough that they were unlikely to leave home (30 and over) (Gutmann et al. 2002). We contrast these to adults who are not children of the head. In fewer than 1% of households were there both sons older than 10 years of age and unrelated men.

The distribution of observations across time and household characteristics is shown in Table 2, along with average farm size and cropped acres. Average farm size grew through 1920, and then leveled off. Average acres in crops continued to increase throughout the period under analysis. The age trajectory of farm holdings follows the theorized shape shown in Fig. 1, with older and younger farmers on smaller farms than middle-aged farmers, and cropped acres peaking in early middle age. Larger households had larger farms and more cropped acres. The age pattern of home leaving is evident in the distribution of households with adult children. Households can be included in more than one composition category. Very few households with teen or adult sons also contained unrelated men, suggesting that the labor of other men was substituted for sons not yet old enough to contribute or who had already left home. Households with adult members have larger average farm sizes than do those with young children in this univariate table, suggesting that labor may be more important for farm size than simple dependency. Cropping shows a similar, but less pronounced pattern. Finally, there is a great deal of variation in the size and intensive use of farms, as evidenced by large standard errors around most means in Table 2.

Spatially, farms are nested within sampled townships and townships are nested within agro-ecological zones. Temporally, individual time is nested within historical time. In other words, we have constructed a longitudinal data file in which repeated measurements on household heads, their households, and farms have intervals that are scaled in terms of the age of household heads, but the aging of household heads is synchronous (but not coterminous) with historical period, thus giving us leverage to separate and quantify age and period effects.

We demonstrate the value of these data and their utility for understanding the theoretical questions we introduced earlier by following the Sparks family, wheat farmers in north-central Kansas, from 1880 to 1940. Joseph Sparks was born in Indiana but raised in Illinois. He moved to central Kansas with his wife and children between 1877 and 1880. He was 29 at the 1880 census, living with his wife, two sons, and two daughters. Five more children were born between 1880 and 1895, giving the couple a total of four daughters and five sons. Combined data from the population and agricultural censuses reveal changes in land use and household composition over Joseph's life. In 1885 at age 34, Joseph's farm was a half-section in size, or 320 acres (solid line, Fig. 3a). As he approached middle age, Joseph doubled the size of his farm to a maximum of almost a full section in 1895 when he was 44 years old. At that time, nine children were at home, four of them sons 13 or older. His three eldest sons left home within the next 10 years. The eldest, William, established his own farm in the same township when in his twenties (dashed line, Fig. 3a). The farms of father and son exactly totaled the acreage of Joseph's farm in the previous census. Our data do not tell us whether Joseph's farm lost the same 215 acres that William's farm gained, and if so whether Joseph transferred the land to William through gift, sale, rental, or other arrangement, but all are possible scenarios. By the time Joseph was 64 all his sons had left home and he was back to farming about a quarter-section (160 acres), which he kept until at least the age of 79. In 1935, at age 84, Joseph had no farm or crop acreage, but he still owned livestock. He died in 1937. As William approached middle age, he increased the size of his farm to 345 acres, which he kept through his fifties, when our records end.

Land cropped by the Sparks family also shows a transfer from the older to the younger generation, one that clearly reflects household labor supply (Fig. 3b). This change was more complete than the transfer of farm land. As Joseph's older sons reached their teen and young adult years, he increased his acres in crops three-fold, from 90 to 270 acres (solid line, Fig. 3b). That census (1895) was the last one in which his older sons lived in Joseph's household. With two sons still at home but also still young, Joseph reduced his crop acres by about one-third over the next 10 years. After all his sons had left home and Joseph reached his mid-60s, the transfer of cropping was complete with Joseph reporting only a few acres of sorghum. William, in turn, began to increase his crop acreage as his Sons matured (dashed line, Fig. 3b). In the following analyses, we use similar information for thousands of Kansas households, telling us who lived in the household, how they used their land, and how household land use changed across time and varied across the landscape. To take full advantage of our rich panel data, the methodology we employ (described in the next section) uses information from all cases, rather than constraining the analysis only to those families, like the Sparks, whom we were able to follow over repeated observations.

Methods

We estimate appropriately specified multilevel growth models to link coefficients to hypotheses derived from our research questions, specifically that the age trajectory of farm land use is related to time, place, and household composition. The multilevel model for change allows us to simultaneously address within-person (household) change in farm size (and acres cropped) and between-person (level-2) differences in change (Singer and Willett

2003). The multilevel model for change is also ideally suited to be responsive to likely sources of regression-based assumption violations. First, our sampling design contains several levels of clustering. Thus, the i.i.d. regression assumptions (errors are independent and identically distributed) are likely violated and unadjusted standard errors biased. We account for temporal and spatial dependence by treating individual time (age) as nested within household head and households as nested within townships. Second, we can easily generalize our regression specification to match our expectation that extensification and intensification are nonlinear functions of age of household head. Third, individual growth models allow us to use information from all known households, including those with only one observation, thus minimizing potential bias from incomplete record linkages.

In the multilevel regression analyses that follow, we analyze how trajectories of land-use were changed by the development of an economy based on family farms, the environmental endowments encountered by farm families, and the changing composition of agricultural households. Specifically, we draw inference from hypotheses about the interconnection between land and labor in the basic life cycle trajectories of farmers and farm households across time and space in Kansas using post-estimation tests on cross-level interactions between the nonlinear trajectories of farm size (and number of cropped acres) and the characteristics of farm and household structure, environmental and historical context. We model the annual absolute change in farm size (and cropped acres) as a nonlinear function of household heads' ages and condition that nonlinear (quadratic) trajectory by interactions with dummy variables that capture historical period (decades), environmental context (Malin zones), and household composition. Our research hypotheses are linked to these cross-level interactions. The interactions show whether the pooled average household head's age-based farm size (and cropland) trajectory is altered by historical period, place, or household/farm composition. We use the routines for longitudinal/panel data multilevel mixed-effects linear regression (xtmixed) in Stata version 10 to estimate our models (StataCorp 2007a, b; West et al. 2007).

In its simplest form, our “unconditional” nonlinear growth model may be written as a two-level mixed model (Singer and Willett 2003):

$$\begin{aligned} y_{ij} &= \pi_{0j} + \pi_{1j}Age + \pi_{2j}Age^2 + \varepsilon_{ij} \\ \pi_{0j} &= \beta_{00} + u_{0j} \\ \pi_{1j} &= \beta_{10} \\ \pi_{2j} &= \beta_{20} \end{aligned} \quad (1a-d)$$

where i indexes the sequence of measurements of household heads' age and j indexes the cross-sectional units (household heads). Furthermore, Eqs. 1a and 1b (lettered from top to bottom) have random terms wherein $\varepsilon_{ij} \sim N(0, \sigma_\varepsilon^2)$ is the conventional (level-1) regression error, but u_{0j} allows an additional source of unexplained variation between household heads (level-2); and Eqs. 1c and 1d show that we treat the slopes for Age and Age^2 as fixed effects. Both of these specifications warrant further explanation and justification.

First, as previously described, our sampling design has spatial and temporal hierarchical structures that are likely sources of clustering that would violate i.i.d. regression assumptions. Random effects regression, of which Eqs. 1a–1d are members, is a standard econometric solution to omitted (or unobserved) variables that underlie sources of correlated error. In short, our growth model yields unbiased inference about the (nonlinear) trajectory of change in the level-1 (Eq. 1a) equation.

Second, our preference for the fixed effects quadratic trajectory of the dependent variable y (farm size, and then, acres in crops) over the life course of household heads is premised on maximizing the available information we have extracted from the agricultural censuses. Our level-1 regression estimates are therefore the result of pooling all known values of y from all household heads and from all agricultural censuses from 1875 to 1930. In essence, we are making a composite growth trajectory from the pooled values of y at each observed age of household head from all of the agricultural censuses from all of the 25 sample townships. Many household heads contribute only one value of y , with one corresponding age, while others contribute only two measurements of y , with two corresponding ages at those points of measurement. Less than 10% of the household heads contribute three or more measurements to our pools of age-specific distributions of y . In aggregate, however, the repeated measurements from these household heads contribute over 40% of the total number of observations in our regression analysis. By using all available information from all household heads, regardless of their persistence in the historical record, we minimize, and hopefully eliminate, the sample selection bias that would result from analytic methods that could only include “stayers” (household heads who contribute, say, three or more repeated measurements). Our approach creates a composite population profile at each observed age of household heads. At some ages, we may still only have one observed value of y , but at most others we are pooling much larger numbers of cases. The resultant trajectory of the quadratic growth curve is a curve that passes through the means of each of the age-specific distributions of y , providing a baseline growth curve. The growth trajectory is a parabola, that is, farm size and cropped acres increase as a function of age until “midlife” and then decreases with older age, shown in Figs. 4a (farm size) and 4b (cropped acres) for the farm households in our data. It is this shape, in addition to the theory described previously, that guides us to model the growth curve as a quadratic polynomial.

The estimated intercept of our multilevel regression model, β_{00} , accounts for unobserved heterogeneity in y among all household heads, but the focus of our inquiry is on the trajectory of change as observed in the composite population profile (constructed from all measurements from all household heads from all time periods from all townships). We model the trajectory of change as a conventional quadratic polynomial. This means that the change in y for each (one) year increase in the age of household head is given by the derivative:

$$\frac{\partial y}{\partial Age} = \beta_{10} + 2\beta_{20}(Age). \quad (2)$$

Equation 2 expresses of the “effect” of an independent variable (Age) on the dependent variable (cf. Stolzenberg 1980) and shows that the effect is not constant over all values of the independent variable (as is the usual case in linear regression). Rather, that effect changes as a function of the value of the independent variable. In line with Fig. 4, the effect is positive at younger ages, but decreasingly so until midlife of the household head, and then the slope becomes negative at older ages. We then examine how this profile changes when we adjust for household-level characteristics, historical period, and environmental region.

Each of our research questions asks whether the unconditional growth curve just described is conditioned by one or more higher level covariates. Formally, answering these questions implies incorporating cross-level interactions into Eqs. 1b–1d, and then properly isolating and testing whether the cross-level interaction changes the unconditional growth curve. To illustrate, we consider whether location/environment conditions the trajectory of y . We proxy environmental regions by assigning households to one of five agro-ecological zones, therefore we incorporate four dummy variables (M1–M4) and reference the Wheat Cattle

Sorghum zone (M5). This generalization alters the equations of the unconditional growth model in the following manner:

$$\begin{aligned} y_{ij} &= \pi_{0j} + \pi_{1j}Age + \pi_{2j}Age^2 + \varepsilon_{ij} \\ \pi_{0j} &= \beta_{00} + \beta_{01}M1 + \beta_{02}M2 + \beta_{03}M3 + \beta_{04}M4 + u_{0j} \\ \pi_{1j} &= \beta_{10} + \beta_{11}M1 + \beta_{12}M2 + \beta_{13}M3 + \beta_{14}M4 \\ \pi_{2j} &= \beta_{20} + \beta_{21}M1 + \beta_{22}M2 + \beta_{23}M3 + \beta_{24}M4. \end{aligned} \quad (3a-d)$$

Incorporation of the agro-ecological dummy variables does not directly alter the level-1 equation (Eq. 1a = Eq. 3a). Rather, Eqs. 3b–d reveal that we are modeling the level-1 parameters, π_{0j} , π_{1j} , π_{2j} , with higher level covariates. In this generalization, it is appropriate to consider agro-ecological zone as a level-2 covariate even though all household heads in an agro-ecological zone are assigned the same indicator variable value.

While 3a–3d are informative, we gain much more insight by writing the reduced form equation. Substituting Eqs. 3b, c, and d into 3a and rearranging, we get the “full” model expression:

$$\begin{aligned} y_{ij} &= \beta_{00} + \beta_{01}M1 + \beta_{02}M2 + \beta_{03}M3 + \beta_{04}M4 + \beta_{10}Age + \beta_{20}Age^2 + \beta_{11}(M1 \times Age) + \beta_{12}(M2 \times Age) + \beta_{13}(M3 \times Age) + \beta_{14} \\ & (M4 \times Age) + \beta_{21}(M1 \times Age^2) + \beta_{22}(M2 \times Age^2) + \beta_{23}(M3 \times Age^2) + \beta_{24}(M4 \times Age^2) + (u_{0j} + \varepsilon_{ij}). \end{aligned} \quad (3e)$$

Equation 3e clearly shows how (and where) we should assess whether the trajectory of change is related to location/environment. We can establish a global test that the growth curve is independent of location/environment by setting $\beta_{11} = \beta_{12} = \beta_{13} = \beta_{14} = \beta_{21} = \beta_{22} = \beta_{23} = \beta_{24} = 0$. This can be done using model selection methods for comparing the fits of restricted and unrestricted models, to determine whether the simpler (restricted) model given by Eq. 4:

$$y_{ij} = \beta_{00} + \beta_{01}M1 + \beta_{02}M2 + \beta_{03}M3 + \beta_{04}M4 + \beta_{10}Age + \beta_{20}Age^2 + (u_{0j} + \varepsilon_{ij}) \quad (4)$$

accounts for as much of the variation in y as did the more complex (unrestricted) model given by Eq. 3e (cf. Gujarati 2003). We use this approach to formally assess whether evidence supports our research questions.

We also rely on a generalization of the expression for marginal effects in polynomial regression given above in Eq. 2 to specifically quantify how each higher level covariate affects the growth curve trajectory over the life course (i.e., Age) of our composite household head. Recall that Eq. 2 shows that the effect of a (1 year) increase in Age on y changes as the value of Age increases. We select ages 30, 45, and 60 as representative points in our composite household head's life to assess how Age affects y over the life course (corresponding to approximately one standard deviation below the mean age, mean age, and one standard deviation above mean age, respectively). We then generalize Eq. 2 to further assess how much the unconditional effect of Age is altered by each higher level covariate. This generalization can be shown by representing any higher level covariate as Z , then writing the “conditional” marginal effect as:

$$\frac{\partial y}{\partial Age|Z} = \beta_{11} + 2\beta_{21}(Age \times Z) \quad (5)$$

where β_{11} represents the coefficient for the interaction between *Age* and *Z*, and β_{21} represents the coefficient for the interaction between *Age*² and *Z*. Tests of incremental improvement between Eqs. 3e and 4, and the age-specific solutions to Eqs. 2 and 5 are easily implemented using the “test” and “lincom” post-estimation options, respectively, in Stata (StataCorp 2007b).

Results

Models were fitted with head's age, head's age squared, year of observation (as a series of dummy variables with 1930 as the omitted category), agro-ecological zone (as a series of dummy variables with Wheat Cattle Sorghum as the omitted category), household size and the household composition indicator variables listed in Table 2, as well as interaction terms for all independent variables with head's age and head's age squared. We treat these terms as fixed effects, grouped by household identifiers to account for within-household correlation of observations across time and unobserved heterogeneity between households.

Our research questions are linked to the interactions with head's age and head's age squared. These interactions indicate whether a selected independent variable alters the baseline growth curves of farm size and crop land shown in the panels of Fig. 4. As with any regression model that includes interaction terms, the marginal effect of the focal variable is different at different levels of the conditioning variable. Some post-estimation manipulation is therefore necessary to expose that marginal effect. In our model, the effects of interest are different at different ages of household head. We solve the interactions at ages 30, 45, and 60 in order to expose the impact of each independent variable over a broad segment of the life course. The results of our post-estimation solutions are presented in Table 3 and discussed later. The evidence from post-estimation tests to determine whether including each pair of the interactions with age and age-squared accounts for more explained variation in farm size or cropped acres is given in the “chi-2” and “*p* value” columns. We use a cutoff of .05 for statistical significance in discussing results (italicized for emphasis in Table 3). In short, *p*-values less than .05 indicate that, holding everything else constant, the regression model that includes that pair of interactions (with age and age squared) is preferred over the simpler model that omits that pair of interactions. Quantities reported under the columns labeled “age 30”, “age 45”, and “age 60” show the marginal effect on the nonlinear growth trajectory: the amount of change at that specific age in the dependent variable (in acres) for a one-unit increase in the independent variable (or the difference between the identity category vs. the reference category for a dummy variable), with positive coefficients adding acres and negative coefficients subtracting acres.

Place: The age trajectory for farm size was dependent on agro-ecological zone. In the Mixed Farming, Corn Belt, Bluestem Pasture, and Central Wheat Belt zones the age trajectory was lower across the life cycle, compared with the age trajectory in the Wheat Cattle Sorghum zone. This interpretation is evidenced in the first panel of Table 3 by the large and statistically significant chi-square statistics and the negative slope coefficients reported at ages 30, 45, and 60. Farms were larger, and more acres were added across the life cycle, in the western region. The four included agro-ecological zones also had fewer acres in crops across head's life cycle than did the Wheat Cattle Sorghum area, although the results for the Central Wheat Belt were not significantly different. In each zone, the magnitude of the effect on both farm size and acres in crops was larger for younger farmers, reflecting the larger farm sizes necessary in the west, with some convergence with other zones as farmers approached the age of divestment. The two wheat-growing zones were the least different in the effect of the age trajectory on farm size and particularly on cropped acres.

Time: The age trajectory of farm size was significantly different in 1875, 1895, 1905, and 1915 than in 1930, the reference category (see second panel in Table 3). In general, farms were smaller across the life course in these earlier years, but less so at older ages. In 1895 and 1915, the effect was negative at the earlier and positive at the latter part of the life course, with smaller farms for younger farmers (compared to 1930) and larger farms for older farmers, perhaps suggesting a delay in transitioning to divestment. In contrast, the age trajectory of farm size in 1905 was shifted upward compared to 1930, with increasing differences across age, suggesting larger farms (on average), and the greatest increase to older farmers with perhaps less old-age divestment in 1905 than in 1930. The age trajectory of cropped acres was also dependent on calendar time in the years up through 1915. In all earlier years except for 1905, younger farmers had fewer cropped acres than younger farmers in 1930, yet older farmers had more (except in 1895). In 1905, farmers at each age had more acres in crops than their counterparts in 1930, with the greatest difference at the older ages. This would suggest that farmers in these earlier decades faced obstacles to cropping early in their careers, continued adding cropped acres later in their careers, and that the 1895 census followed a period particularly adverse to cropping. The age trajectory of farm size in 1920 and 1925 was not statistically different than in 1930.

Household composition: Household size also significantly changed the age trajectory for farm size, particularly at younger ages (see third panel in Table 3 and the magnitude of slopes at age 30 relative to age 45, and at age 45 relative to age 60). A larger household was a disadvantage through middle age, and an advantage by age 60, even when controlling for the age and sex composition of the household, as well as region and year. Cropping was also related to household size, with more additional acres in crops for each additional household member across the life course. Older minor children, unmarried daughters (or daughters-in-law) aged 23 through 29, and sons aged 18 through 29 all shifted the age trajectory of farm size upward, with decreasing magnitude over the life course of the household head (see supporting evidence in Table 3). For example, farm households with teenaged members had, on average, larger farms than farm households headed by farmers of the same age who did not have teenagers, controlling for other factors, and this advantage was smaller for older farmers. The presence of young children significantly altered the age trajectory of cropped acres, compared to farmers of the same age without young children in the household. Young children were associated with more acres in crops for younger heads, but their effect shifted over the head's life course, so that middle- and older- aged farmers with co-resident young children had fewer cropped acres than middle- and older-aged farmers with no young children in the household. Older minor girls and unmarried daughters (or daughters-in-law) in their mid to late twenties were associated with an upward shift in the age trajectory of cropped acres, as were sons age 23 and older, both with decreasing effect over the head's life. Households with other women in their mid-to late-twenties (unrelated women, married daughters, etc.) had fewer acres in crops, compared to other farmers of the same age without such women in their households, and controlling for other factors. Similarly, the presence of men who were not sons had a generally negative, but not statistically significant, effect on acres in crops across head's life course.

Discussion and conclusions

The fundamental theoretical underpinning for our analysis is the assertion from the agricultural economics and farm size literature that farm size is tightly linked to age, with three phases: entry and establishment, growth and survival, and divestment. Our results demonstrate that head's age is an important component of farm extensification and farm intensification in a representative area of the US Great Plains, in ways that are compatible with the prior findings of other researchers working in similar environments (e.g., Boehlje 1973; Gale 1994), and with some, but by no means all, of those working in very different

environments (e.g., Walker et al. 2002). In much of this work (reviewed in de Sherbinin et al. 2008; Walker et al. 2002), farmer's age is treated as an incomplete measure of household life cycle stage, is often not included in the analysis, and when included does not often contribute to explanations of land use. Conversely, we find a powerful effect of head's life course on land use that endures in the face of other household demographic characteristics (such as the age of children) that indicate household life cycle. The farmers in the 25 townships of our Kansas sample entered farming at lower levels of land holdings and cropped acres, expanded and intensified their farms through middle age, scaled back on intensive land use as they aged, and divested themselves of farm acres in old age. An important finding of our work is that this process is strongly related to time period. First, the basic life course strategy just described was much less pronounced in the years closer to settlement, probably for the reasons argued by Potter and Lobley (1992), Attack and Bateman (1987), and Easterlin (1976). In frontier settings, divestment is unnecessary and possibly unprofitable because sons can obtain land with their own resources. The era of relatively inexpensive land lasted until the total acres included in farms, and the acres under cultivation, reached their maximum in Kansas shortly after the turn of the twentieth century. Second, short-term changes in economic conditions—in this case, the years of drought preceding the 1895 and 1915 censuses—also had an impact, possibly delaying the establishment of new, young farmers by discouraging in-migration, encouraging out-migration, or postponing intergenerational transfers. The delaying effect of land clearance on the age trajectory of intensive land use is visible in the results for cropped acres. Younger farmers had a harder time expanding cropping in the earlier decades than did young farmers in later decades, when much of the cropland had already been cleared and more machines were used to break the tough prairie sod. Cropping in 1895 was shifted downward across the life course, likely also in response to the extreme drought of 1894 in the western agro-ecological zones of the state.

Just as important as the role of time period is our ability to discern the impact of environmental variation on the fundamental age-based life cycle of the farm. The environmental region in which farmers established themselves was related to absolute farm size and cropped acres, and this relationship was strongest for younger farmers. In the more arid western zones, dominated by wheat fields and extensive cattle ranges, young farmers needed more acres to establish a farm than did their counterparts in eastern Kansas, yet also had to increase their acreage more rapidly to reach a viable farm size by middle age. Our findings take into account other aspects of the farm household, and highlight the importance of environmental opportunities and constraints in shaping land use.

The size of farm families was an important component of this age trajectory of land use. In general, large households were associated with larger farms and more cropped acres. Our analysis was not able to address the causal question of farm size and family size raised by Clay and Johnson (1992) and others. However, the finding that the relationship between household size and farm size changed over the head's life course adds nuance to these discussions. Large households did not help younger farmers to build their farms, but did provide older farmers with either the opportunity or the necessity to postpone divestment. Also, intensification through cropping was enabled by larger households across the life course. Beyond the simple question of household size, the age, gender, and relationship to head of household members are important correlates of land use over the head's life course and can shed light on questions of consumption and production. Composition has several interacting axes: age, sex, and relationship reflect dependence, productive capability, productive activity, human capital investment, and future transfers. Household composition played an important part in how household size was related to farm intensification and extensification over the head's life course in Kansas. Adult household members who were probably hired hands (not the sons and daughters of farm couples) did not advantage the

households in which they resided across the age trajectory, either in terms of growing and maintaining larger farms, or in encouraging farmers to grow more crops, no matter what the farmer's age. On the other hand, children too young to contribute substantially to the farm enterprise did have an upward effect on farm size and cropping for younger farmers, suggesting that farmers may have been primarily responding to the current and future needs of their families.

Taken together, these findings suggest that farm size was driven by the needs of dependents (consumption and future divestment), rather than by available labor (production capacity). Young adult children were particularly important in building and retaining large farms with more intensively used acres, and consistent with the agricultural economy literature, children entering their teens appeared to have initiated intensified investment in farm extension. As farmers aged, the advantage they gained from co-resident children diminished, perhaps signaling that farm households that did not transition to the younger generation were in some other way at a disadvantage.

While age and relationship to household head provide valuable insights into the relationship between family and farm, some of our most intriguing findings are that teenage daughters had a greater effect on farm size and particularly on cropped acres than did teenage sons, and that older daughters (and daughters-in-law) appear to have had the largest effect on both the size of farms and intensified cropping. This result is surprising because, while previous work in historical US settings and the contemporary developing world finds a strong role for women and children, and girls in particular (Cain 1977; Caldwell 2005; Effland 2005; Flora 1985; Flora and Stitz 1988; Hunter and Riney-Kehrber 2002; Neth 1994; Riney-Kehrberg 2001; Sylvester 2001b; VanWey et al. 2007), the work of women and young children was undervalued and sons were strongly preferred as successors (Beale 1979; Gjerde and McCants 1999; Leonard and Gutmann 2006; Lobao and Meyer 2001; Rosenfeld 1985; Sachs 1983; Salamon 1992). The value of women's production was nearly half the net income of farms in the mid-1930s (Monroe 1940), but women were generally not involved in activities that produced field crops, and the values of women's production was earmarked for consumption and maintenance, while men's was earmarked for farm expenses and land acquisition (Fink 1987). Indeed, in our Kansas farm households, daughters still at home in their twenties contributed through off-farm wages (13% were schoolteachers) and diversified farm activities not reflected in cropped acres, and these contributions could well have been substantial. Some sixth of the households with both sons and daughters in their twenties were three-generation families that would require and encourage a continuing large and productive operation.

Our findings for household size and composition suggest that labor *per se* was less important in farmers' decisions to acquire or divest land, and to increase or decrease cropping, than were issues of capital accumulation and farm viability, providing for children and farm succession. Cropped acres are not an end in themselves. They produce cash to continue the farm enterprise and capital to expand. These two aspects of land use are thus synergistic: more cropped acres can buy more farm acres, which can then be cropped. The onset of childbearing, particularly early childbearing, may have prompted farmers to crop more in order to expand the farm to provide for all their children, both sons and daughters. Both older daughters and sons contributed to growing the farm, with most children leaving home in their late teens and early twenties. Older daughters, who could work outside the home and provide income in cash that could be invested in the farm, may have played a critical role. Households with sons in their later twenties may have represented a transition period in the household, where the father retained headship, but father and son together built the farm up to accommodate the son's transition to marriage and his own household. The lack of a significant finding linking older sons to more acreage may tell us that co-resident

joint farming was more prevalent when sons were younger, either as a means to establish sons before they struck out on their own, or because the death of the father or the transfer of headship created a new household with a younger head.

Our goal has been to use our unique Kansas data to test a core set of theories about agricultural families in the era before modern mechanized farming. Those theories link household head's life course and household life cycle development with farm cycles, and explain the size of farms and the amount of land devoted to crops as a function of the age of the farmer, the life cycle of the household, and the labor endowment of the family, all within a broad context that takes into account all household members, time period, and environment. Historical and environmental contexts reveal the importance of time and place without diminishing the importance of the head's life course or of the household life cycle. The semi-arid grasslands of Kansas imposed constraints and shaped opportunities in ways that left families little choice but to adapt or leave. Many, such as the Sparks of Rooks County, did adapt and stayed for generations. Our study ends as farm consolidation and increased inequality were beginning to alarm social scientists (Coffman 1979; Goldschmidt 1947; Grimes 1931). Viewing adaptation through life cycle and life course helps us to understand how families manage their resources to build and maintain farms in diverse environments.

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Fig. 1.
Life cycle and land-use change: family labor, farm acres, and cropped acres

Fig. 2. Map of Kansas showing sample townships and Malin's land-use zones (Sylvester and Cunfer 2009; *Source: James C. Malin (1944) Winter Wheat in the Golden Belt of Kansas, preface.*)

Fig. 3.
a Life cycle and land-use change: family labor and farm acres on the Sparks family farm. **b**
 Life cycle and land-use change: family labor and crop acres on the Sparks family farm

Fig. 4.
a Farm size by household head's age: Kansas Sample Townships. **b** Cropped acres by household head's age: Kansas Sample Townships

Table 1

Characteristics of Malin's zones

	Mixed farming	Bluestem pastures	Corn belt	Central wheat belt	Wheat, cattle, sorghum
Elevation (feet)	929.67	1150.33	1396.50	1659.17	2973.22 *
Mean annual precipitation (inches)	32.66 *	27.33 *	23.85 *	20.98 *	15.04 *
Relative July humidity	53.67	52.67	54.50	47.33 *	41.67 *
Mean July temperature (F)	79.37	79.37	78.58	79.92	78.22
Mean January temperature (F)	32.43	31.10	26.65 *	30.55	30.33
Non-productive farmland (%)	16.61 *	10.20 *	29.57 *	5.63 *	23.95 *
Topography	Irregular plains	Open hills	Irregular plains, Open low hills	Irregular plains, Plains w/hills, Tablelands w/mod. relief	Smooth plains, Irregular plains
Farm size (acres)	167.79	229.05	162.81 *	248.02 *	509.03 *
Cropped land (acres)	67.24	69.48	79.28 *	153.22 *	188.85 *

Note:

* Different from all other Malin zones at $p > .01$ in OLS regression with Wald post-estimation tests for equivalence of the betas

Table 2

Time period and household characteristics: Mean farm size, mean acres in crops, and distribution

	Farm acres		Crop acres		Dist. %
	Mean	StdDev	Mean	StdDev	
Overall	251	236	114	114	100.00
Time period					
1875	148	115	44	36	8.84
1885	189	157	66	57	10.48
1895	209	187	98	93	12.25
1905	255	258	105	91	13.48
1915	266	255	123	121	14.88
1920	315	278	145	130	13.34
1925	281	242	144	126	13.88
1930	293	253	154	142	12.85
Household characteristics					
Head aged less than 30	224	202	112	101	14.32
30 to 44	254	231	120	116	40.26
45 to 60	266	254	116	118	30.93
60 and over	237	240	97	111	14.49
1 to 4 household members	224	215	101	101	50.61
5 to 9	271	246	124	120	44.88
10 or more	355	313	169	161	4.51
Children (0–10)	257	232	121	117	58.90
Girls (11–17)	275	253	127	125	27.87
Boys (11–17)	277	252	129	127	30.36
Daughters (18–22)	286	257	131	122	10.13
Daughters (23–29)	289	273	131	147	3.89
Sons (18–22)	304	271	144	137	14.30
Sons (23–29)	297	262	138	143	6.95
Sons (30 +)	281	272	126	154	2.76
Other women (18–22)	313	316	136	144	2.02
Other women (23–29)	303	270	142	142	1.65

	Farm acres		Crop acres		Dist. %
	Mean	StdDev	Mean	StdDev	
Other men (18–22)	325	330	132	121	3.29
Other men (23–29)	344	334	142	150	3.38
Other men (30 +)	308	300	132	137	5.69

Table 3

Effects of interactions of life cycle trajectories, land-use zone, calendar time, and household composition

	Farm size				Cropped acres					
	Chi sq.	p	Age 30	Age 45	Age 60	Chi sq.	p	Age 30	Age 45	Age 60
Regional land-use zones										
Corn belt	48.28	0.000	-7.38	-6.20	-5.02	39.66	0.000	-3.34	-2.78	-2.22
Mixed farming	27.99	0.000	-6.66	-5.49	-4.33	27.69	0.000	-3.68	-2.95	-2.22
Bluestem pastures	27.22	0.000	-7.15	-5.82	-4.49	42.65	0.000	-4.67	-3.73	-2.79
Central wheat belt	30.79	0.000	-5.46	-4.61	-3.76	5.00	0.082	-0.75	-0.67	-0.58
Wheat, cattle, sorghum (omitted category)										
Year										
1875	8.44	0.015	-5.01	-3.53	-2.05	20.81	0.000	-0.55	-0.11	0.33
1885	5.26	0.072	-2.81	-1.94	-1.07	34.52	0.000	-0.86	-0.33	0.20
1895	15.78	0.000	-1.12	-0.48	0.16	34.36	0.000	-1.28	-0.73	-0.19
1905	6.49	0.039	0.13	0.34	0.55	21.23	0.000	0.16	0.33	0.50
1915	11.01	0.004	-0.63	-0.19	0.24	26.84	0.000	-0.45	-0.13	0.19
1920	2.44	0.296	-1.13	-0.76	-0.39	0.00	0.885	0.25	0.18	0.11
1925 (1930 omitted category)	0.39	0.822	-0.67	-0.49	-0.31		0.715	0.17	0.16	0.16
Household life cycle and labor										
Household size	17.31	0.000	-0.36	-0.18	0.01	28.03	0.000	0.01	0.07	0.13
Children (0-10)	2.60	0.273	0.43	0.19	-0.04	14.09	0.001	0.03	-0.13	-0.28
Female children (11-17)	7.88	0.020	4.31	3.27	2.22	21.38	0.000	3.14	2.36	1.57
Male children (11-17)	7.48	0.024	1.25	0.77	0.29	0.53	0.768	0.17	0.10	0.04
Daughters (18-22)	0.84	0.657	NA	4.15	3.18	3.39	0.183	NA	1.96	1.39
Daughters (23-29)	6.04	0.049	NA	19.37	15.70	7.71	0.021	NA	10.68	8.49
Sons (18-22)	6.84	0.033	NA	1.78	1.02	3.76	0.153	NA	0.40	0.18
Sons (23-29)	9.98	0.007	NA	8.25	7.07	9.11	0.011	NA	1.98	1.82
Sons (30 +)	0.57	0.751	NA	NA	4.87	6.48	0.039	NA	NA	3.98
Other women (18-22)	0.90	0.638	-2.45	-1.95	-1.45	0.12	0.942	-0.36	-0.29	-0.23
Other women (23-29)	4.22	0.121	-3.88	-3.28	-2.67	6.40	0.041	-2.67	-2.20	-1.74
Other men (18-22)	0.29	0.865	0.08	0.00	-0.07	0.67	0.716	-0.68	-0.51	-0.34
Other men (23-29)	2.06	0.357	1.78	1.25	0.73	3.91	0.141	-0.93	-0.82	-0.72

	Farm size					Cropped acres				
	Chi sq.	p	Age 30	Age 45	Age 60	Chi sq.	p	Age 30	Age 45	Age 60
Other men (30 +)	0.86	0.650	1.64	1.29	0.94	3.05	0.218	0.83	0.59	0.35

Notes: NA indicates structural zeros (e.g., heads aged 30 with sons or daughters aged 18 and older); $p < .05$ in italics for emphasis